

# Development of a 4-GEM large-size prototype for the ALICE TPC upgrade \*

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ALICE at the LHC at CERN is planning a major upgrade of the central barrel detectors, including the TPC, to cope with an increase of the LHC luminosity after 2018. A full-size prototype of a TPC Inner Read-Out Chamber (IROC) was produced and tested during the test-beam campaign in the fall of 2014. It was equipped with a quadruple Gas Electron Multiplier (GEM [1]) employing GEM foils with a pitch of  $140\ \mu\text{m}$  ("Standard" - S) and  $280\ \mu\text{m}$  ("Large Pitch" - LP). The subsequent GEM foils in the stack have been installed according to the S-LP-LP-S configuration presented schematically in fig. 1. The design and assembly procedure of the 4-GEM prototype follows closely that of the triple GEM prototype built and tested in 2012 and described in details in [2, 3]. A notable modification with

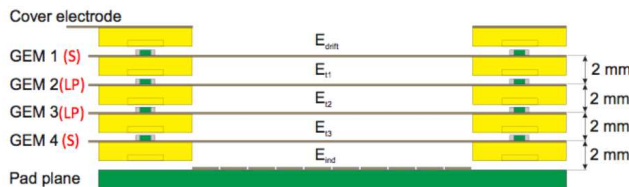


Figure 1: Schematic picture of the 4-GEM IROC

respect to the 2012 setup is that the induction gap (between GEM4 and the pad plane) was reduced from 4 mm to 2 mm. The new 4-GEM IROC employs also a cover electrode, which is used to minimise drift-field distortions at the edges of the GEM stack.

Several HV settings were used with the prototype, including the one defined as 'baseline' for the ALICE GEM readout chambers optimised for the ion backflow and energy resolution [4]. A resistor chain was used to supply the potentials on the subsequent GEM electrodes. The GEM IROC was installed in a test field cage with a drift length of 115 mm and commissioned with radioactive sources. The prototype is operated in Ne-CO<sub>2</sub>-N<sub>2</sub> (90-10-5) gas mixture, which is the nominal gas mixture for the upgraded TPC.

Figure 2 shows a gain curve obtained for the prototype using a <sup>55</sup>Fe source. The gain is scaled with a common scaling factor (*SF*) applied to all GEM potentials. The nominal gain of 2000 is obtained for *SF*  $\approx$  100%. The value of ion backflow corresponding to this setting is 0.63% and the energy resolution of a <sup>55</sup>Fe peak  $\sigma = 11.3\%$  [4].

The  $dE/dx$  resolution of the prototype was evaluated in a test beam campaign at the CERN PS with

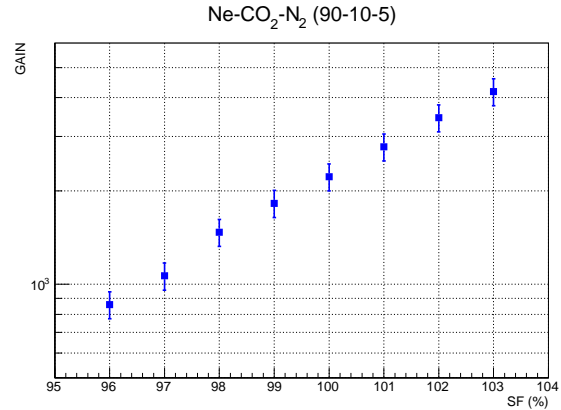


Figure 2: Gain curve obtained in Ne-CO<sub>2</sub>-N<sub>2</sub> (90-10-5) for the 4-GEM IROC using scaled 'baseline' HV settings.

1 GeV/c pions and electrons. The relative energy resolution  $\sigma(dE/dx)/\langle dE/dx \rangle$  obtained for electrons ( $\sim 9.1\%$ ) and pions ( $\sim 10.4\%$ ) is comparable to the resolution of the MWPC IROC [4].

Stability of the chamber was evaluated in a test beam at the CERN-SPS. The discharge probability was measured using showers of hadrons produced by a high-intensity secondary pion beam with a momentum of 150 GeV/c impinging on a 30-40 cm thick iron absorber. The average beam intensity was  $\sim 6 \times 10^6$  particles per spill, resulting in an average in-spill rate of  $\sim 1.2$  MHz. The number of particles accumulated during the experiment is  $N_{\text{tot}}^{\text{SPS}} = (4.7 \pm 0.2) \times 10^{11}$ . The chamber was operated with the 'baseline' settings at the gain of 2000. In total, three discharges were detected in the detector. This translates into a discharge probability of  $(6 \pm 4) \times 10^{-12}$  per incoming hadron. This result is of the same order of magnitude as the one obtained by the LHCb Collaboration where the discharge probability of 3-GEM detectors operated with an isobutane-CF<sub>4</sub>-based gas mixtures was measured under similar conditions [5].

## References

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